RECOMMENDATION ITU-R M.1187-1

A method for the calculation of the potentially affected region for a mobile-satellite service network in the 1-3 GHz range using circular orbits

(Questions ITU-R 83/8 and ITU-R 201/8)

(1995-2006)

Scope

This Recommendation defines the term "active service arc" and provides a method for the calculation of an "affected region" when assigning frequencies to space stations of MSS systems operating between 1 and 3 GHz and for giving assistance in the identification of administrations whose assignments may be included within this "affected region".

The ITU Radiocommunication Assembly,

considering

a) that there is a need to develop Recommendations on coordination methods, the necessary orbital data relating to non-geostationary (non-GSO) satellite systems, and sharing criteria;

b) that non-GSO satellite systems implementing these MSS allocations may have different constellations, with different altitudes, and different inclination angles;

c) that "active service arc" needs to be defined;

d) that there is a need to define the area where other services, including MSS, might be affected and where coordination may be performed for which the relevant criteria and methods are not defined in this Recommendation;

e) that there is a need to further define the concept of an "affected region" (which is not to be confused with the "coordination area") for MSS operating between 1 and 3 GHz,

recognizing

1 that Chapter III of the Radio Regulations (RR) which includes the procedure for effecting coordination for MSS systems for certain bands within the Table of Frequency Allocations of the Radio Regulations within the frequency range of 1-3 GHz,

recommends

1 that "active service arc" should be defined as: the locus of orbital points in an MSS constellation that describes where the satellites are transmitting or receiving. The MSS operator calculates the arc utilizing those system specific characteristics such as the constellations orbits, spacecraft antenna characteristics, e.i.r.p., which achieves its service objectives for a particular service area;

2 that when a specific active service arc is published, the methodology in Annex 1 could be used to assist in the identification of administrations whose assignments may be included in the "affected region" as defined in Annex 1 (see Note 1).

NOTE 1 – This methodology could be further improved by taking into account more precise technical characteristics of the MSS system.

Annex 1

A method for the calculation of the potentially affected region for an MSS network in the 1-3 GHz range using circular orbits

1 Introduction

This Annex defines a methodology for calculating the "affected region". This affected region should be used to identify co-frequency MSS and other services with equal or higher status in other administrations that might be affected by operation of the MSS network. First, the locus of points of the satellite's orbital arc are plotted that correspond to points where the satellite would be active in order to cover its service area. Then, the corresponding sub-satellite locations are plotted on the Earth's surface. The affected region is then defined to be these areas on the Earth within visibility of the spacecraft and referenced to the perimeter of the sub-satellite locus.

This methodology to calculate the affected region identifies the administrations whose co-frequency assignments might be affected.

It is recognized that another methodology of determining affected frequency assignments of other administrations with respect to an MSS space station and its associated service area could be used and that the incorporation of this methodology into an ITU-R Recommendation would not make its use mandatory.

Use of this methodology for calculating an affected region does not change the status (primary or secondary) of the radio services within that region.

2 Calculation of the affected region

Let the quadrilateral A depicted in Fig. 1 represent the active sub-satellite area needed to serve an administration for a representative MSS system. Note that the sub-satellite area is not necessarily coincident with the borders of the administration. The distance, *D*, depicted in Fig. 1 is the distance from the outer perimeter of A to the field of view (FOV) point from the satellite. The FOV is defined as extending to the limits of the visible horizon as seen from the satellite. The total affected region is then the total area calculated from the edges of the sub-satellite area out to the distance *D*. For circular constellations distance *D* will be a constant great circle distance which increases with increasing satellite altitudes.

2.1 Calculation of width of affected region envelope

This section presents a methodology to calculate the distance that should be used to draw the outer perimeter around the active sub-satellite areas to create the affected region.

Figure 2 illustrates the calculation of the outer perimeter distance *D*, which is the distance from the edge of the sub-satellite area A to the FOV of the satellite at the active area outer edge. The affected region is defined as follows:

Affected region: an area on the Earth's surface calculated by defining a distance from the perimeter of the active sub-satellite area A, a distance *D* from the perimeter of the active sub-satellite sub-area, corresponding to the maximum field of view from the satellites at the perimeter of the active service arc. The region also includes administrations within the active sub-satellite area.

Active service arc and active sub-satellite area are defined as follows:

Active service arc: see the definition in *recommends* 1.

Active sub-satellite area: the projection down the nadir from the active service arc to points on the Earth's surface. The perimeter of this area is defined in geocentric coordinates (latitude/longitude).

FIGURE 1

Representation of an active sub-satellite area required to serve an administration and its corresponding affected region

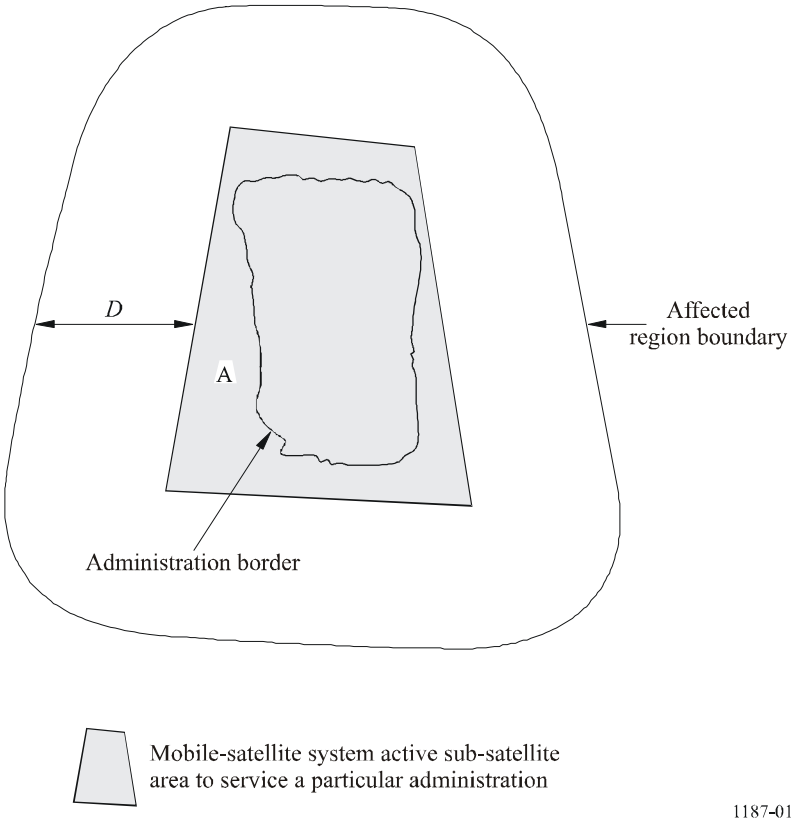
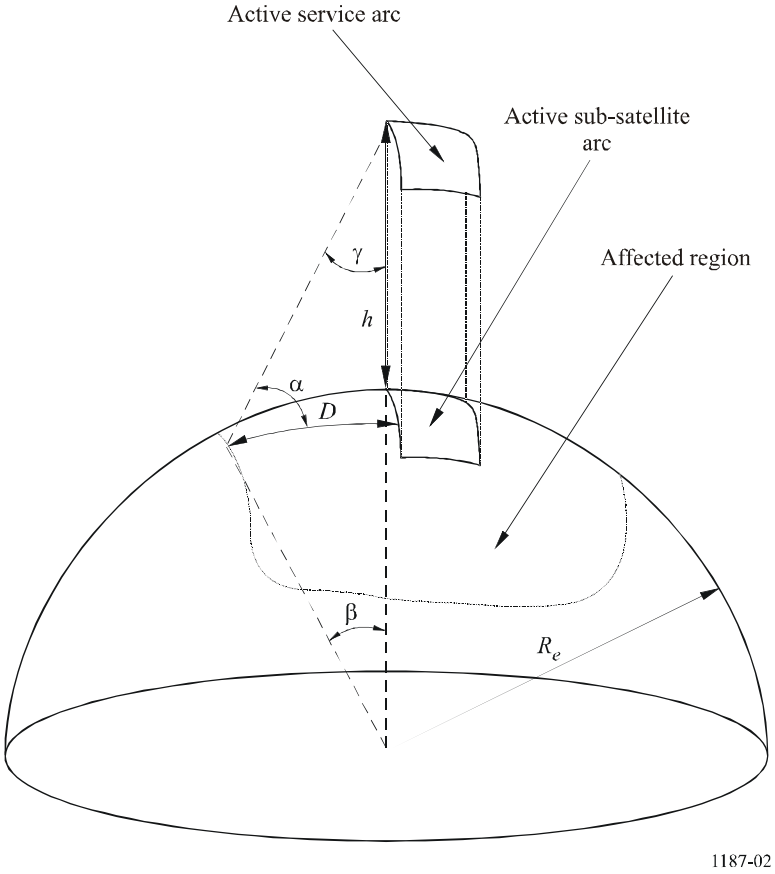


FIGURE 2

Geometry required to calculate *D*, envelope distance around sub-satellite area



Definition of variables:

R_e: Earth radius

h: satellite altitude

γ: nadir angle from satellite at sub-satellite perimeter edge to its field of view distance

β: geocentric angle from sub-satellite area edge to field of view distance

α: elevation angle

D: Earth distance from active sub-satellite area perimeter to 0° elevation angle point (maximum field of view limits).

The necessary formulae to calculate the distance D:

$$\beta = \cos^{-1}[R_e/(R_e + h)] \quad (1)$$

$$D = R_e \beta \qquad \text{rad} \quad (2)$$

Once D has been calculated, it can be used to determine the affected region in conjunction with the sub-satellite area.

2.2 Example calculation of an affected region

This section gives an example of how to calculate the affected region for a mobile-satellite system intending to provide service within the territory of an administration. The example administration is Italy, and Fig. 3 illustrates the sub-satellite area for servicing Italy for the LEO A (see Recommendation ITU-R M.1184) mobile-satellite system.

FIGURE 3

Hypothetical sub-satellite active area for Italy

The necessary parameters to calculate the affected region are:

Satellite altitude:	780 km
Earth radius:	6 367 km
Sub-satellite area width:	1 140 km
Sub-satellite area length:	1 625 km

Note that the sub-satellite active area was chosen assuming the service area was the Italian administration and is only an example. The actual sub-satellite area for Italy of any mobile-satellite system may be quite different depending on the satellite networks system specific characteristics.

Using equations (1) and (2) for this case, $\beta = 27°$ and $D = 3\,000$ km, so the distance D to add around the sub-satellite area is 3 000 km. Therefore, for the example sub-satellite area in Fig. 3, the affected region would extend into North-Western Sudan, Western Russia (including Moscow), Northern Norway and Mauritania.